In re Patent Application of:
YAO
Serial No. **10/736,859**
Filed: **12/16/2003**
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IN THE CLAIMS:

Claims 1-18 (cancelled).

19. (new) A method of generating an electrical current in response to light comprising the steps of:

(a) absorbing light by a light-absorption intrinsic semiconductor layer having a thickness ti, a doping concentration below 5e14 cm^{-3}, and producing, in response to light absorbed by said light-absorption intrinsic semiconductor layer, electrical carriers that are transported therethrough;

(b) absorbing light by a first light absorption doped semiconductor layer doped with one of p- and n-conductivity type-determining impurities, having a thickness td1, and a first doping concentration dc_1 between 1e17 and 2e18 cm^{-3}, said first light absorption doped semiconductor layer having a first surface thereof abutting a first surface of said light absorption intrinsic semiconductor layer, and producing, in response to light absorbed by said first light absorption doped semiconductor layer, electrical carriers that are transported therethrough, and wherein td1/ti is greater than or equal to 0.17; and

(c) extracting electrical current comprised of said carriers produced by and transported through said light-absorption intrinsic semiconductor layer and said first light absorption doped semiconductor layer, by means of a first electrode electrically coupled to said first light absorption doped semiconductor layer, and a second electrode electrically coupled to said light absorption intrinsic semiconductor layer.

20. (new) The method according to claim 19, wherein

step (b) further comprises absorbing light by a second light absorption doped semiconductor layer doped with the other of said p- and n-conductivity type-determining impurities, having a thickness td2, and a second doping concentration dc_2 between 1e17

and 2e18 cm^{-3}, said second light absorption doped semiconductor layer having a first surface thereof abutting a second surface of said light absorption intrinsic semiconductor layer that is spaced apart from said first surface of said light absorption intrinsic semiconductor layer by material of said light absorption intrinsic semiconductor layer therebetween, and producing, in response to light absorbed by said second light absorption doped semiconductor layer, electrical carriers that are transported therethrough, and wherein (td1+td2)/ti is greater than or equal to 0.17, and

step (c) comprises extracting said electrical current, comprised of said carriers produced by and transported through said light-absorption intrinsic semiconductor layer and said first and second light absorption doped semiconductor layers, by means of said first electrode electrically coupled to said first light absorption doped semiconductor layer, and said second electrode electrically coupled to said second light absorption doped semiconductor layer.

21. (new) The method according to claim 20, wherein said first light absorption doped semiconductor layer comprises a light absorption p-doped semiconductor layer and said second light absorption doped semiconductor layer comprises a light absorption n-doped semiconductor layer, and wherein

step (c) comprises extracting said electrical current by means of a p-doped anode electrode electrically coupled to a second surface of said light absorption p-doped semiconductor layer, and an n-doped cathode electrode electrically coupled to a second surface of said light absorption n-doped semiconductor layer.

22. (new) The method according to claim 19, wherein the total thickness td1+ti of said first light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer is greater than $v/(2f_{3-dB})$ by 20% or more,

In re Patent Application of:
YAO
Serial No. **10/736,859**
Filed: **12/16/2003**

where v is the saturation drift velocity of either an electron or a hole, whichever is smaller, in said light absorption intrinsic semiconductor layer, and wherein $f_{3\text{-}dB}$ is the frequency at which the amplitude of responsivity of said method is reduced to $1/\sqrt{2}$ of its DC low-frequency value.

23. (new) The method according to claim 20, wherein the total thickness td1+td2+ti of said first and second light absorption semiconductor layers and said light absorption intrinsic semiconductor layer is greater than $v/(2f_{3\text{-}dB})$ by 20% or more, where v is the saturation drift velocity of either an electron or a hole, whichever is smaller, in said light absorption intrinsic semiconductor layer, and wherein $f_{3\text{-}dB}$ is the frequency at which the amplitude of responsivity of said method is reduced to $1/\sqrt{2}$ of its DC low-frequency value.

24. (new) The method according to claim 19, wherein, at a 3-dB bandwidth frequency of 40DHz or higher, said first light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer are InGaAs lattice-matched to InP, and the total thickness (td1+ti) of said first light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer is greater than 0.60 microns.

25. (new) The method according to claim 19, wherein, at a 3-dB bandwidth frequency of 40GHz or higher, said first light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer are InGaAs lattice-matched to InP, and the total thickness (td1+ti) of said first light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer is greater than 0.65 microns.

In re Patent Application of:
YAO
Serial No. **10/736,859**
Filed: **12/16/2003**
______________________/

26. (new) The method according to claim 19, wherein, at a 3-dB bandwidth frequency of 40DHz or higher, said first light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer are InGaAs lattice-matched to InP, and the total thickness (td1+ti) of said first light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer is greater than 0.70 microns.

27. (new) The method according to claim 20, wherein, for a 3-dB bandwidth frequency of 40GHz or higher, said first and second light absorption doped semiconductor layers and said light absorption intrinsic semiconductor layer are InGaAs lattice-matched to InP, and the total thickness (td1+td2+ti) of said first and second light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer is greater than 0.60 microns.

28. (new) The method according to claim 20, wherein, for a 3-dB bandwidth frequency of 40GHz or higher, said first and second light absorption doped semiconductor layers and said light absorption intrinsic semiconductor layer are InGaAs lattice-matched to InP, and the total thickness (td1+td2+ti) of said first and second light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer is greater than 0.65 microns.

29. (new) The method according to claim 20, wherein, for a 3-dB bandwidth frequency of 40GHz or higher, said first and second light absorption doped semiconductor layers and said light absorption intrinsic semiconductor layer are InGaAs lattice-matched to InP, and the total thickness (td1+td2+ti) of said first and second light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer is greater than 0.70 microns.

In re Patent Application of:
YAO
Serial No. 10/736,859
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30. (new) A photodiode structure for generating an electrical current in response to light incident thereon comprising:

a light-absorption intrinsic semiconductor layer, having a thickness ti and a doping concentration below 5e14 cm^{-3}, which is operative to absorb light incident thereon and to produce, in response said incident light absorbed thereby, electrical carriers that are transported therethrough;

a first light absorption doped semiconductor layer doped with one of p- and n-conductivity type-determining impurities, and having a thickness td1 and a doping concentration dc_1 between 1e17 and 2e18 cm^{-3}, and having a first surface thereof abutting a first surface of said light absorption intrinsic semiconductor layer, and which is operative to absorb light incident thereon and to produce, in response to said incident light absorbed thereby, electrical carriers that are transported therethrough, and wherein td1/ti is greater than or equal to 0.17; and

an electrode arrangement for extracting electrical current comprised of said carriers produced by and transported through said light-absorption intrinsic semiconductor layer and said first light absorption doped semiconductor layer, said electrode arrangement including a first electrode electrically coupled to said first light absorption doped semiconductor layer, and a second electrode electrically coupled to said light absorption intrinsic semiconductor layer.

31. (new) The photodiode structure according to claim 30, further comprising a second light absorption doped semiconductor layer doped with the other of said p- and n-conductivity type-determining impurities, having a thickness td2, and a doping concentration dc_2 between 1e17 and 2e18 cm^{-3}, said second light absorption doped semiconductor layer having a first surface thereof abutting a second surface of said light absorption intrinsic semiconductor layer that is spaced apart from said first

surface of said light absorption intrinsic semiconductor layer by material of said light absorption intrinsic semiconductor layer therebetween, said second light absorption semiconductor layer being operative to absorb light incident thereon and to produce, in response to said incident light absorbed thereby, electrical carriers that are transported therethrough, and wherein (td1+td2)/ti is greater than or equal to 0.17, and wherein

said electrode arrangement is operative to extract electrical current comprised of said carriers produced by and transported through said light-absorption intrinsic semiconductor layer and said first and second light absorption doped semiconductor layers, and includes said first electrode electrically coupled to said first light absorption doped semiconductor layer, and said second electrode electrically coupled to said second light absorption doped semiconductor layer.

32. (new) The photodiode structure according to claim 31, wherein said first light absorption doped semiconductor layer comprises a light absorption p-doped semiconductor layer and said second light absorption doped semiconductor layer comprises an n-doped semiconductor layer, and wherein

said electrode arrangement comprises a p-doped anode electrode electrically coupled to a second surface of said light absorption p-doped semiconductor layer, and an n-doped cathode electrode electrically coupled to a second surface of said light absorption n-doped semiconductor layer.

33. (new) The photodiode structure according to claim 30, wherein the total thickness td1+ti of said first light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer is greater than $v/(2f_{3-dB})$ by 20% or more, where v is the saturation drift velocity of either an electron or a hole, whichever is smaller, in said light absorption intrinsic semiconductor layer, and wherein f_{3-dB} is the frequency at which

the amplitude of responsivity of said photodiode structure is reduced to $1/\sqrt{2}$ of its DC low-frequency value.

34. (new) The photodiode structure according to claim 31, wherein the total thickness td1+td2+ti of said first and second light absorption semiconductor layers and said light absorption intrinsic semiconductor layer is greater than $v/(2f_{3\text{-dB}})$ by 20% or more, where v is the saturation drift velocity of either an electron or a hole, whichever is smaller, in said light absorption intrinsic semiconductor layer, and wherein $f_{3\text{-dB}}$ is the frequency at which the amplitude of responsivity of said photodiode structure is reduced to $1/\sqrt{2}$ of its DC low-frequency value.

35. (new) The photodiode structure according to claim 30, wherein, at a 3-dB bandwidth frequency of 40DHz or higher, said first light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer are InGaAs lattice-matched to InP, and the total thickness (td1+ti) of said first light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer is greater than 0.60 microns.

36. (new) The photodiode structure according to claim 30, wherein, at a 3-dB bandwidth frequency of 40GHz or higher, said first light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer are InGaAs lattice-matched to InP, and the total thickness (td1+ti) of said first light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer is greater than 0.65 microns.

37. (new) The photodiode structure according to claim 30, wherein, at a 3-dB bandwidth frequency of 40DHz or higher, said first light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer are InGaAs lattice-matched to InP, and the total thickness (td1+ti) of said first light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer is greater than 0.70 microns.

38. (new) The photodiode structure according to claim 31, wherein, for a 3-dB bandwidth frequency of 40GHz or higher, said first and second light absorption doped semiconductor layers and said light absorption intrinsic semiconductor layer are InGaAs lattice-matched to InP, and the total thickness (td1+td2+ti) of said first and second light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer is greater than 0.60 microns.

39. (new) The photodiode structure according to claim 31, wherein, for a 3-dB bandwidth frequency of 40GHz or higher, said first and second light absorption doped semiconductor layers and said light absorption intrinsic semiconductor layer are InGaAs lattice-matched to InP, and the total thickness (td1+td2+ti) of said first and second light absorption doped semiconductor layer and said light absorption intrinsic semiconductor layer is greater than 0.65 microns.

40. (new) The photodiode structure according to claim 31, wherein, for a 3-dB bandwidth frequency of 40GHz or higher, said first and second light absorption doped semiconductor layers and said light absorption intrinsic semiconductor layer are InGaAs lattice-matched to InP, and the total thickness (td1+td2+ti) of said first and second light absorption doped semiconductor layer

and said light absorption intrinsic semiconductor layer is greater than 0.70 microns.